CCAMLR

Commission for the Conservation of Antarctic Marine Living Resources
Commission pour la conservation de la faune et la flore marines de l'Antarctique
Комиссия по сохранению морских живых ресурсов Антарктики
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Revised proposal for continuing research on Antarctic toothfish (Dissostichus mawsoni) in Statistical Subarea 48.6 in 2021/22 from a multiyear plan (2021/22–2023/24): Research Plan under CM 21-02, paragraph 6(iii)

Delegations of Japan, South Africa and Spain

EN

Revised proposal for Continuing Research on Antarctic toothfish (*Dissostichus mawsoni*) in Statistical Subarea 48.6 in 2021/22 from a multiyear plan (2021/22-2023/24): Research Plan under CM21-02, paragraph 6(iii)

Delegations of Japan, South Africa and Spain

Abstract

A collaborative research program has been undertaken by Japan and South Africa since 2013 to enhance data collection and analysis in the subarea 48.6 under CM 21-02. Spain joined the proposal starting from 2018/19 fishing season in order to contribute to the data acquisition and to speed up the integrated assessments of the Antarctic toothfish *(Dissostichus mawsoni)* stock in this subarea (WG-FSA-18/34).

The continuation of the three-member research proposal for 2021/22 season is presented to ensure continuity of previous research activities[1]. Data and investigations about the population structure and various demographic parameters of *D. mawsoni* using trotline (JPN and ZAF) and Spanish longline (ESP) gears, established tagging techniques, pop-up tags and genetic analysis will provide the basis for the development of spatial population models and assessments in support of management advice. An Integrated Stock Assessment (ISA) which takes into account the tag time series from southern research areas of Subarea 48.6 is going to be continually developed until the end of the 2023/24 season.

Based on suggestion from WG-SAM-2021 (report of WG-SAM-2021, para 8.4), the research plan have been revised as follows:

- Explaining the importance of understanding stock connectivity between research blocks in the area (seamounts versus continental shelf),

- indicating further details about how the stock structure will be represented in the planned CASAL assessment for the region,

- increasing the otolith sampling rate from "10 otoliths per 5 cm length bin" to "20 otolith per 5 cm length bin), and

- indicating minimum sampling requirements for by-catch species and designed to meet the research objectives.

The WG-SAM-2021 recalled that a structured fishing design was necessary to optimise tagging performance evaluation (report of WG-SAM-2021, para 8.4). However, as already described in 3(a) "Research survey/fishing design", the area is not suitable to set a stratified sampling design

[1] The proponents considers that the "New" research plan for the exploratory fishery for *Dissostichus mawsoni* (toothfish) in the Statistical Subarea 48.6, which the proponents intends to submit to the SC and relevant WGs this year, should be formally reviewed as a proposal of a new research plan if it is officially determined that the reviews of both 2019/20 and 2020/21 survey results are to be completed by the Scientific Committee (SC) and its subsidiary Working Groups (WGs). If the SC and WGs are to be held as informal meetings this year, the proponents would like to continue the survey based on the current (on-going) research plan for the following years until the completion of formal review by the SC.

as the fishing grounds with broad environmental characteristics such as a complex of seamounts, hills and ridges is expected to be small relative to the size of the research block. Therefore, no depth stratification is proposed in the current research plan.

The updated CCAMLR Research Plan – Research Proponent Self-Assessment can be found in Appendix 1.

1. Main objective

(a) Objectives for the research and why it is a priority for CCAMLR

The overriding aim is to strengthen the basis of stock assessments for Antarctic toothfish (*Dissostichus mawsoni*) and ecosystem understanding in a data-poor area, by using traditional and new technology. In Subarea 48.6 the long-term goal is the development of Integrated Stock Assessment (ISA) models using CASAL or any other modeling framework as is currently done in other regions of the Convention Area to set the catch limits using CCAMLR decision rules. The models will be improved by applying it to current hypotheses and generating new testable ones about distribution and movement patterns of Antarctic toothfish population stock structures. Models developed under the ISA framework make predictions about the abundance, size/age structure, as well as relative numbers of tagged and untagged Antarctic toothfish at particular locations within a subarea. Because these models utilize location-specific observations from the fishery to fit fish movement functions, surveys in locations where data has not been accumulated to conduct an ISA are of particular value to the assessments underlying management advice.

From the 2016/17 season onwards, four research blocks were designated in Subarea 48.6 where catch limits applied to each research block (Figure 1).

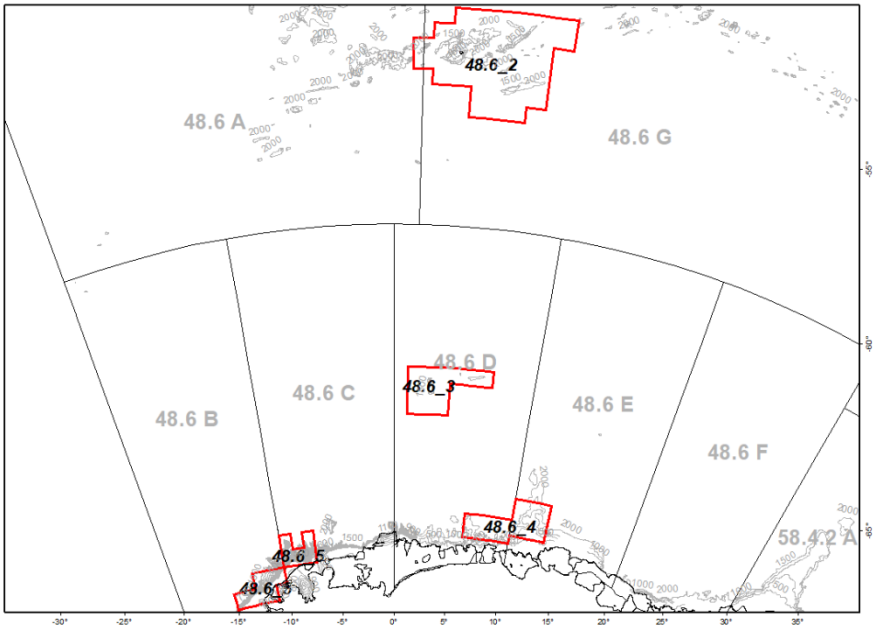

Figure 1. Research blocks to be surveyed in Subarea 48.6 (gray contours show 1,000 m and 2,000 m isobaths).

The research plan concentrates fishing effort in locations where tagged fish have been released to increase the amount of data and the number of tags available for recapture as shown in paragraphs 3.128 & 3.129 of SC-CAMLR-XXX (SC-CAMLR-XXX, 2011), and this fishing

strategy has been in place since the joint survey by Japan and South Africa started in 2013-14. At the same time, we aim to maximize tag-recapture and data collection to the extent possible under the precautionary exploitation rate.

The main aim of this research plan is to provide the data required for:

- **Objective 1**: Providing an assessment of the stock status including size/age structure of *D. mawsoni*,
- **Objective 2**: Investigating ecological traits of *D. mawsoni*, and
- **Objective 3**: Improving the knowledge about Antarctic marine ecosystems

(b) Detailed description of how the proposed research will meet the objectives, including annual research goals (where applicable)

Objective 1: Providing an assessment of the stock status including size/age structure of D. mawsoni

Catch, effort and tag-recaptured data have been updated and used for estimation of toothfish stock status. Analysis of ancillary data (such as ecological traits of *D. mawsoni*, Obj. 2) will also be conducted to improve the understanding of the potential stock hypothesis that will form the basis of developing ISAs to be conducted in Subarea 48.6.

According to comments for CASAL model received in previous WGs (e.g., WG-FSA-2019 report, para. 4.65-4.67, WG-SAM-2021 report, para 8.4), following issues will be focused under Obj. 1;

- Improving fits of modelled data to the age-length keys (ALK) by increasing sampling effort and age readings and using simulations to test the effect of otolith sample number and length class binning on ALKs and calculated growth parameters,
- Attempting a two-area population model by incorporating inferred movement between the population in the seamounts and that in the shelf areas for CASAL assessment, and
- Testing the utility of collating all available data when attempting a CASAL stock assessment to identify gaps, for example parameters from other areas that have existing CASAL assessments.

Objective 2: Investigating ecological traits of D. mawsoni

Conventional tag-recapture data, pop-up satellite archival tags (PSATs) data, biological measurement such as length, weight, sexual maturity, stomach contents or age data derived from readings of processed otoliths are considered essential to investigate ecological traits of Antarctic toothfish (e.g. population structures, growth, movement and reproduction). Calibration of otolith readings in this subarea between proponents will be updated as soon as new data are accumulated.

The Antarctic toothfish populations within the proposed key areas will be characterized based on longline catches and tag-recapture data. Three potential stock hypotheses for *D. mawsoni* in the Atlantic and adjacent regions of the Southern Ocean were proposed in WS-DmPH (WG-SAM-18/33). Collection of various information mentioned in the previous paragraph over Area 48 are indispensable to test these different hypotheses. As outcomes of previous research programs, it is hypothesized that *D. mawsoni* used northern areas (48.6_2 and 48.6_3) as spawning grounds, and shelf areas (48.6_4 and 48.6_5) as nursery ground. This hypothesis will be tested by intensive tag

release and recapturing, PSAT, associated biological samples, and other scientifical technics already used in other research program, such as genetic approach, isotope analysis, and model simulation.

It is expected to analyze trace elements on sets of otoliths, and results to tie in with the Stock hypothesis. This will be made through a specific contract with the South Atlantic Environmental Research Institute (SAERI).

Objective 3: Improving the knowledge about Antarctic marine ecosystems

Comprehensive bycatch data and related observation (e.g., interactions with predators such as seabirds and marine mammals) collected in accordance with relevant Conservation Measures (33-03, 41-01, and 41-04) will help to reveal the spatio-temporal pattern of distribution and relative abundance of the main bycatch species including key ecosystem components such as seabirds, marine mammals, sharks, skates, and Vulnerable Marine Ecosystems (VME).

Environmental data collection will entail the attachment of conductivity, temperature and depth loggers (CTD loggers). Information about sea-ice conditions will be recorded by using satellite image data. The environmental data will be contributed to develop statistical model approach such as habitat model and VAST, for both *D. mawsoni* and other components of marine ecosystems. Potentially, the environmental data will be shared with the Southern Ocean Observing System (SOOS), delivering additional value from the proposed research program.

A Benthic Video Camera (BVC) has been used routinely onboard the Tronio during the research operations as well as the CTD.

The timeline of the proposal milestones in 2021/2022-2023/2024 fishing seasons correlated with objectives Obj.1–Obj.3 in Subarea 48.6 is shown in Table 1. The final reports of the total series of research fishing will be submitted to CCAMLR WG-FSA in 2024.

Table 1: Milestones timeline for the proposal in 2021/2022-2023/2024 fishing seasons. Alphabets in columns showed the proponents shared role of three fishing states: J, Japan; S, South Africa; E, Spain.

	2022		2023		2024	
	SAM	FSA	SAM	FSA	SAM	FSA
SURVEY FISHING		J-S-E		J-S-E		J-S-E
Obj 1. Stock assessment						
1.1. Reviewing Stock hypothesis						J-S-E
1.2. Developing ISA models	J-S-E	J-S-E	J-S-E	J-S-E	J-S-E	J-S-E
1.2.1 CPUE standardization				J-S-E		J-S-E
Obj 2. Ecological traits						
2.1. Ageing toothfish		J-S-E		J-S-E		J-S-E
2.2. Updating Age-Length Key		J-S-E		J-S-E		J-S-E
2.3. Deploying PSATs		J-S-E		J-S-E		J-S-E
2.4. Collecting tissue sample for DNA		S-E		S-E		S-E
Obj 3. Antarctic Marine ecosystem						
3.1. Bycatch pattern		J-E		J-E		J-E
3.2. Macrobenthic bycatch pattern		J-E		J-E		J-E
3.3. Depredation		J-S-E		J-S-E		J-S-E

(c) Rationale for research, including relevant existing information on the target species from this region, and information from other fisheries in the region or similar fisheries elsewhere

Present exploratory fishing data from 48.6, 58.4.2, and 58.4.1 suggest a stock structure hypothesis of *D. mawsoni*; the west of Prydz Bay region (50-70°E; SSRUs 58.4.2C and D) seems to be an important nursery ground and adults showed wide range of migratory patterns between offshore and shelf areas (north- and southward migrations for spawning and feeding, respectively; Okuda et al., 2018). Ichii et al. (2019) examined movements of tagged Antarctic toothfish (*Dissostichus mawsoni*) for 48.6 in relation to life history hypotheses. Connectivity studies between 48.2 and 48.4 have been made (Söffker and Belchier, 2017). This proposal intends to explore this connectivity issue further with a special focus on research block 48.6_2 and 48.6_3.

This year we conducted an updated analysis of long-distance movements of tagged *D. mawsoni* that were released or recaptured in 48.6 during the period of 2008-2021. It should be noted that not only east-west movements but also, for the first time, north-south movements were observed. As for the former, five between-subareas movements occurred, while, as for the latter, five northward movements from the shelf areas (nursery ground) and northern areas (spawning ground) occurred (see details in "the Final report of research fishing operations at Subarea 48.6" submitted to WG-FSA-2021). Furthermore, one PSAT tag successfully recovered, which also showed northward migration. Information on such north-south movements is important to develop the structure of CASAL model in 48.6.

From the Workshop that took place in February 2018 in Berlin "Towards the development of a stock hypothesis for Antarctic toothfish (*Dissostichus mawsoni*) in Area 48", three potential stock hypotheses were proposed for *D. mawsoni* population in the Atlantic and adjacent regions of the Southern Ocean. The above-mentioned updated analysis supports the single Atlantic population hypothesis so far.

An updated analysis of sea-ice and oceanography (e.g. sea surface temperature, SST) indicated the possibility to predict the accessibility to research blocks 4 and 5 (Namba et al., 2019a, b). Although SST in the southern part of the 48.6 subarea has decreased in 2019, the SST anomalies were in warmer mode in the last three years (Figure 2). The daily SST anomaly in 2021has been the lowest since 2016 (Namba et al, 2021). The SST plots for 20 years in 2002-2021indicates that higher SST spikes in RB5 occurred in 2003, 2005-2006, 2011 and 2017-2018 and the lower spikes occurred in 2007-2009, 2012-2016 and 2021.

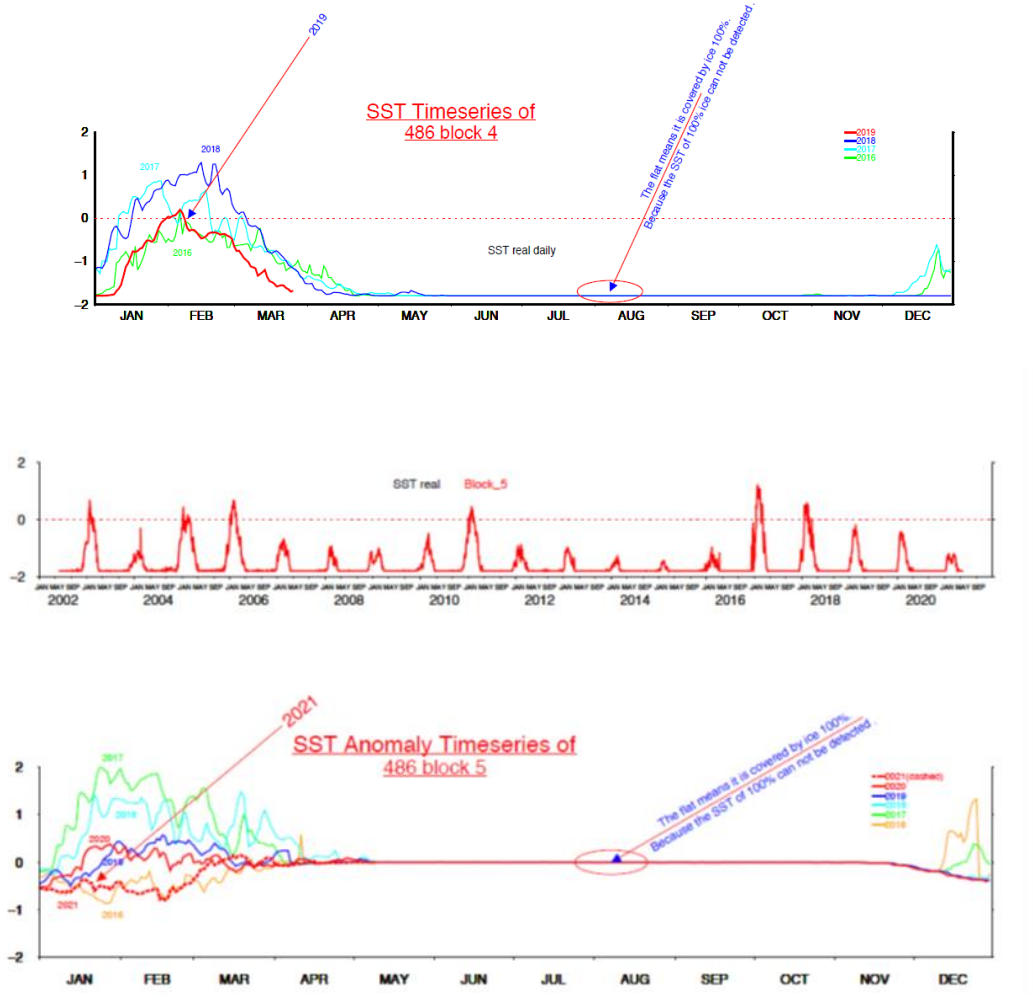

Figure 2. SST time-series in research blocks 486_4 between 2016 and 2019 and 486_5 between 2016 and 2019 with 20 years daily plot of SST (upper).

Among the results that have been presented annually to CCAMLR WGs, remarkable findings in recent years from this research plan are listed here:

- Stock hypothesis in region for Subarea 48.6 and Divisions 58.4.2 and 58.4.1 (WS-DmPH-18/06)
- Updated biological parameters of *Dissostichus mawsoni* at Subarea 48.6 (WG-SAM-2019/36)
- Movements of tagged Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 48.6 in relation to stock structure hypotheses (WG-FSA-2019/05)
- Progress on the integrated stock assessment by CASAL for Antarctic toothfish *Dissostichus mawsoni* in Subarea 48.6 (WG-FSA-2019/21)
- Statistical modelling of by-catch patterns: a preliminary case study using research fisheries in Subarea 48.6 (WG-SAM-2019/09)
- Possibility of predicting sea-ice concentration (SIC) in research block (RB) 48.6-5 (Southern part of Subarea 48.6) using sea surface temperature (SST) in RB 48.6-2 (Northern part of 48.6) (WG-FSA-2019/49)
- Revealing local population structure of Antarctic toothfish (*Dissostichus mawsoni*) within the CCAMLR Subarea 48.6 by otolith chemistry (WG-FSA-18/75)

- Spatial modeling of bycatch patterns for research fishing operations in Subarea 48.6 using VAST (Document presented in WG-FSA 2020 e-group discussions)

Moreover, following points are applied according to the proponents that the commitments considered in the SC-CAMLR-XXXVII in 2018:

1) A BVC has been deployed on the Tronio, and video data will be analysed in order to establish the impact of Spanish longline gear on benthic sessile organisms.
2) An EM system has been installed on Tronio to help monitor setting/hauling operations (Figure 3),
3) PSATs have been deployed, to verify movement and improve stock hypothesis,
4) A Valeport CTD has been deployed to obtain data for oceanographic studies. Water current data at depth are being analysed in order to evaluate the geostrophic current by means of salinity and sea temperature with a numerical model data (Hybrid Coordinate Ocean Model, HYCOM), and
5) Proponents have tried to have a spatial overlap between vessels, to compare vessel effects.

Figure 3: Video monitoring sensor on the setting room door of Tronio.

Although a significant research progress has been made in this subarea since 2012/13, there is still not enough information to characterize the toothfish populations and to conduct robust stock analysis, like ISA models, within this research subarea. Further data collections and analyses in a data-poor area using traditional and new technology will enhance our knowledges of the basic biological features of *D. mawsoni* and facilitate the development of assessment models.

2. Fishery operations

(a) Fishing members

Research will be carried out by Japan, Spain, and South Africa.

(b) Vessel to be used

Member	Japan	Spain	South Africa
Vessel name	Shinsei-maru No.8	Tronio	Koryo maru No.11
Vessel owner	TAIYO A & F CO., LTD.	Pesquerías Georgia S.L.	TAFISA (Pty) LTD.
Vessel type	Commercial bottom Longline fishing vessel	Commercial bottom longline fishing vessel	Commercial bottom Longline fishing vessel
Port of registration	Yaizu-Japan, 143676	Cillero	Cape Town-South Africa, 10908
Registration number	SO1-1372	3ª-GC-1-2-05	
Radio call sign	7KFU	ECJF	ZR 7955
Overall length	57.85 m	55 m	62.6 m
Overall tonnage	1062 tonnes	1058 tonnes (GRT)	1119.9 tonnes
Equipment used for determining position	GPS FURUNO GP-170	VMS-c	GPS FURUNO GP500
Fishing capacity	10 tonne/day	30 tonne/day	10 tonne/day
Fishing processing and storage capacity	14.6 tonne/day, 750 m^3	30 tonne/day, 635.3 m^3	10 tonne/day, 491 m^3

(c) Target species

Dissostichus spp. will be the targeted species caught, and the focus for Obj. 1 and 2.

(d) Fishing or acoustic gear to be used

Member	Japan	Spain	South Africa
Vessel name	Shinsei-maru No.8	Tronio	Koryo maru No.11
Longline type	Trot Line	Spanish longline system	Trot Line
Other sampling gear	Temperature and depth loggers, PSAT (MiniPAT; Wildlife computers)	Conductivity, temperature and depth (CTD) loggers	
		Benthic video cameras	
		Archival tags (MiniPAT; Wildlife computers)	
Type of acoustic gear and frequency	FCV-1900, 28kHz/50kHz		FURUNO FCV-1200L & FCV-1500M, 38kHz/200kHz

(e) Fishing regions (divisions, subareas and SSRUs) and geographical boundaries

Member	Japan	Spain	South Africa
Vessel name	Shinsei-maru No.8	Tronio	Koryo maru No.11
Regions	Blocks 48.6_2, 48.6_3, 48.6_4, and 48.6_5 in Subarea 48.6	Blocks 48.6_2, 48.6_3, 48.6_4, and 48.6_5 in Subarea 48.6	Blocks 48.6_2, 48.6_3, and 48.6_4 in Subarea 48.6

(f) Estimated dates of entering and leaving the Subarea 48.6

Member	Japan	Spain	South Africa
Vessel name	Shinsei-maru No.8	Tronio	Koryo maru No.11
Month	Jan-Jul	Feb-Apr	Dec-Mar

3. Survey design, data collection and analysis

(a) Research survey/fishing design (description and rationale)

Spatial arrangements or maps of stations/hauls (e.g. randomized or gridded)

Research blocks

The selected research blocks 48.6_2 to 5 are those given in CM 41-04 and shown on Fig.1.

Survey plan

We expect further progress on tagging research in the Southern research blocks during the next season because several tags released in the preceding seasons began to be recaptured in recent season. According to the sea-ice condition trends for the last seasons, it is highly likely that fishing between December-April might be suitable. If catch has reached the limit for a given research block, research fishing will cease.

Stratification according to e.g. depth or fish density

Because the area is broadly characterized as a complex of seamounts, hills and ridges, the amount of habitat shallower than 2,500 m is expected to be small relative to the size of the research block. Therefore, no depth stratification is proposed in the current research plan except for a prohibition on exploratory toothfish fishing in depths shallower than 550 m (CM 22-08).

Calibration/Standardisation of sampling gear

The gear configuration of the vessels is described in Table 2. The number of hooks per set ranging 3,500-5,000 will be deployed in accordance with the CM 41-01.

Table 2: Gear configuration of the vessels

Member	Japan	Spain	South Africa
Vessel name	Shinsei-maru No.8	Tronio	Koryo-maru No.11
Longline type	Trotline	Spanish system (Double line longline)	Trotline
Leader or anchor line diameter	18 mm	20 mm green polysteel	18 mm
Leader or anchor line length	200 m	Variable depending on the line length and depth	Variable depending on the line length
Main line diameter	16 mm Polyester/Nylon	16 mm	16 mm
Main line length	9,000 -18,000 m***	5,000 – 9,000 m	9,000 m
Hook type	APO Straight 10/0 hook and 70 mm length	Hook of J/J/Circle (Mustad/Stell)	APO Straight 10/0 hook and 70 mm length
Space between hooks	N/A	1.6m	
Fishing line diameter		5 mm	
Number of baskets per main line		60 – 100	
Number of hooks per main line	Between 3,500 and 5,000	Between 3,500 and 5,000 (maximum 5,000 in this research)	Between 3,500 and 5,000
Distance between droppers	More than 20 m*		50 m*
Length of dropper	More than 8 m*		25 m*
Number of droppers per main line	Between 200 and 601*		180*
Integrated weight	N/A	6kg every 38.5m	N/A (concrete weight 8kg)
Anchor weight	More than 60kg Bar-anchor with or without stone weight for main line; more than 6kg weight on bottom of dropline**	About 80kg	About 64kg (8 x 8 concrete weights)
Bait species	Flying squid, Pilchard, Mackerel, etc.	Herring (HER), or squids (SQA and GIS)	Mackerel, Pilchard, Squid, Pacific Saury, etc.

* Adjust the number of droppers per main line, length of dropper, and number of hooks per dropper attached to each haul to comply with the number of hooks per haul ranging 3,500-5,000 (Conservation Measure 41-01 Annex 41-01/B).

** Anchor weight may be adjusted for each haul for the following reasons; 1) the weight of the drop line is made of concrete and scraped off while using it, and 2) when the tidal current is strong, a stone weight may be added to the bar anchor to stabilize the fishing gear.

*** Generally, the operation will be implemented with the same gear configuration as in previous years. However, it is possible to change a fishing gear configuration, especially main line length, in order to operate more efficiently so that the research operation can be completed during a limited cruise time.

A full description of gear configuration and deployment is located in the CCAMLR Fishing Gear Library (http://www.ccamlr.org/en/publications/fishing-gearlibrary). Additional information about longline deployments, such as minimum separation distance and soak time, can be found in the Data Collection Plan for Exploratory Fisheries (Conservation Measure 41-01 Annex 41-01/A). Details on the fishing gears and deployment methods, as well as variables that can be difficult to control (e.g. soak time and percentage of hooks baited), will be recorded so they may be standardized posteriori.

The new vessel, Shinsei-maru No. 8 has replaced Shinsei-maru No.3 during the 2019/20 fishing season, but since the crew and fishing gear (fishing method: Trot system) are the same, there is no expectation of serious impact on the continuity of the survey.

Proposed number and duration of stations/hauls

To maximize data collection and released tags, the vessels will cooperate to carry out operation as far as possible until reaching the Catch limit determined in CM 41-04. Research hauls will be deployed in accordance with "3 n mile rule" (CM 41-01, Annex 41- 01/B) and maximum number of hooks is 5,000.

Tagging rates and other performance metrics such as tag overlap statistics for tagging programs

The tagging performance will take place fully complying with paragraph (2) of Conservation Measure 41-01 Annex 41-01/C (Conservation Measure 41-01, 2018), such that;

a) only fish suitable for tagging, in accordance with the suitability criteria in the CCAMLR Tagging Protocol, shall be tagged and released;

b) the length frequency of tagged fish will reflect the length frequency of the catch;

c) the vessel will achieve a minimum tag overlap statistic of 60%; and

d) in regions where two toothfish species (*Dissostichus mawsoni* & *D. eleginoides*) co-occur such as in the north of 48.6, the tagging rate will be in proportion to the species and lengths of each *Dissostichus* spp. present in the catches.

In addition, toothfish will be tagged at a rate of at least five fish per ton green complying with Conservation Measure 41-04 (Conservation Measure 41-04, 2018).

According to the recommendation of WG-SAM-16, Japan tagged 5 Antarctic toothfish with PSAT tags in the 48.6 subarea as a trial experiment, but failed to recover any signals until today (presumably, due to the early pop-up below ice). 6 PSAT have been deployed in the 48.6_4 and 48.6_5 research blocks by Spain in the 2018/19 season, with a pop-up time span from 9 months to 1 year. But these also failed to transmit any signals to date. Although Japan planned to release 13 PSATs in 2019/20 fishing season at Subarea 48.6, the operation schedule was largely disturbed and only three PSATs could be released (one at 48.6_4, two at 48.6_3) due to COVID-19. Spain plans to release PSAT tags in RB 2 and 3 where it is expected to have better detection results.

Tag survivability and detection rate estimates will be evaluated using “Toolbox” for preparing research proposal in coordination with the Secretariat.

Other requirements

None.

(b) Data collection: Types and sample size or quantities of catch, effort and related biological, ecological and environmental data (e.g. sample size by location/haul)

Table 3. Summary of data collection by each participating Member. ESP – Spain; JPN – Japan; ZSA – South Africa

Data type	Member	Number/size of samples	Collection method/device	Objective
Catch and effort	All	Every longline deployment. All fish will be identified to species where possible, including those lost at the surface.	Catch and effort data will be recorded and reported according to CCAMLR CMs in force within the proposed SSRUs (summarized in CMs 41-05 and 41-11)	1
Toothfish biological data:Length (cm), weight (kg), sex and maturity.Plus female gonad weight (g).	All	25 toothfish per set will be sampled following the SISO requirements in accordance with CMs 23–07 and 23–04. Additionally, stomach and liver weights will be made and stomach contents will be checked. The physical condition and the hooking condition will be checked for each fish caught.	Maturity and stomach contents will be determined by visual inspection at sea.	1, 2
Muscle tissue samples	ZSA, ESP	Two toothfish per set will be sampled for muscle tissue for stable isotope and/or DNA analysis. ESP will collect and analyze DNA samples from all research blocks.		
Trace elements	JPN, ESP	Trace element work on sets of otoliths		
Toothfish ageing data	JPN, ESP	10 random otolith per set, additional otoliths will be extracted as needed to complete a 10 × male and 10 × female distribution for each 5cm length bins.	According to CCAMLR guidelines	1
Toothfish tagging	All	Five fish per retained tonne (green weight). See section 3 (a) "*Tagging rates and other performance metrics such as tag overlap statistics for tagging*" programs.	T-bar tags in accordance with the CCAMLR Tagging Protocol.	1, 2
	ESP	PSAT tags in RB 2 and 3.		
Environmental data and information about benthic ecosystems		ESP will deploy at least 20 stations CTD equipment in all research blocks. The resulting data will be compared with the Hybrid Coordinate Ocean Model (HYCOM), which provides global daily temperature, salinity at depth etc..	Seafloor will be recorded by acoustic equipment as described in "2. Fishery operations" CTD, data logger and BVC will be attached to fishing gear. ESP will use a Valeport CTD profiler. The FastCTD probe is protected by a stainless-steel frame and was fitted to the anchor line. JPN will use an autonomously deployable data logger for temperature and depth (DST Centi-TD, Star-Oddi Ltd.), which can be installed and collected easily. ESP lost the BVC during deployments in 48.6_2 in last season and for next surveys it will be replaced by a lighter one (Figure 4) that is expected a better success.	3
Seafloor depth (m)	JPN, ZSA			
Temperature	ESP, JPN	ESP will deploy a benthic video camera (BVC) to study substrate composition, density and species composition of benthic invertebrates, as well as the three-dimensional structure of benthic communities if possible.		
Salinity	ESP			
Substrate composition	ESP			
Benthic species composition	ESP			
By-catch biological data; Length (cm), weight (kg), sex and gonad weights (if feasible)	All	For *Macrourus spp*., which is the major by-catch species, up to 30 fish per set will be sampled. For the other by-catch species, up to 10 fish per set will be sampled. VME indicator taxa weight (kg) will be recorded and collected/photographed (if feasible) by scientific observers according to CM 22-07.		3
Interaction with predators (seabirds and marine mammals) and effect of depredation	All	Vessel operators will record any observations of depredatory marine mammals to understand influences of depredation on catch rates and the survival of the released toothfish. If the predators such as sperm whales and killer whales occur around the vessel, the vessel will avoid them to the extent practicable.	The photographic identification data for killer whales will be collected in the region where possible.	3

Figure 4: Benthic Camera that is going to be purchased by Tronio to use in Subarea 48.6.

(c) Method for data analysis to achieve the objective in 1(a)

Objective 1: Providing an assessment of the stock status including size/age structure of D. mawsoni

Currently, local stock estimations of toothfish at Subarea 48.6 have been conducted using the "CCAMLR trend analysis" using both CPUE-seabed method and mark-recapture analysis (i.e., Chapman estimation) in research blocks 2, 3, 4, and 5 separately.

Our research plan aims to realize stock assessment using Integrated Stock Assessment model using CASAL (Bull et al., 2012) to comply with CCAMLR standard.

Integrated Stock Assessment model will utilize the following data; toothfish catch (number and weight), number of tagged and released fish, number of recaptured fish, catch length and age composition. Different scenario of depredation and IUU catches will be tested to provide a range of potential status and harvest rate which lead to precautionary catch limits.

The difference in catch efficiency among vessels, and effective tagging survival and tag detection rates will be investigated using GLM and/or an adequate modelling approach.

Otoliths will be read every year according to CCAMLR standard aging protocols by experienced readers. Sub-sample of otoliths is re-extracted from all otoliths collected during research operations based on size-composition in order to cover full length distribution selected by the fishery.

Biological parameters including estimates for growth, length-weight relationship, maturity, and natural mortality will be updated annually with the new collected data. Age Length Keys will be calculated using time series of ageing data to inform an age-structured CASAL model. A calibration between readers will be made and an age-length key and length-weight relationship will be updated regularly.

A preliminary CASAL assessment has been presented in 2019 (Sawada et al, 2019) and updated in 2021(that will be presented in the FSA-WG in 2021) but additional data or model arrangement might help to improve the model quality to conduct the future stock assessment of *D. mawsoni* in subarea 48.6.

Objective 2: Investigating ecological traits of D. mawsoni

The tagged-recaptured information will be used for movement analysis by investigating moving distance and direction. A long series of tag-recaptured data and catch at age is needed to estimate the natural mortality using tagging data. Sensitivity analysis will be done, and as long as the proposal is progressing, it will potentially be possible to achieve this multiyear milestone.

The results of DNA analysis and PSAT data processing will contribute towards improving the knowledge about population structure of toothfish. For the otolith microchemical analysis of *D. mawsoni*, we are collaborating with Chinese colleague (Prof. Guoping Zhu). His group is building experimental procedures under the suggestions from the well-experienced international scientists.

Genetic studies carried out by La Laguna University (Spain) showed no distinction between 48.6 subarea and 5841 division. They used the amplification and sequencing of the Cyt b, ND2 and 16S rRNA genes. On the other hand, the South Atlantic Environmental Research Institute (SAERI) is carrying out genetic analyses using SNPs (Single Nucleotide Polymorphic loci) but results are not yet available.

Trophic transfers from organic-matter sources to higher trophic levels will be traced using stable isotope ratios and fatty acid profiles (if possible). Diet composition will be investigated from stomach contents data.

Objective 3: Improving the knowledge about Antarctic marine ecosystems

Species composition, catch rates, and size distributions of bycatch organisms (including VME indicators) will be summarized, and comparative analysis of the bycatch organisms will be conducted among gear types and/or among sites. Spatial abundance patterns of bycatch species will be assessed using appropriate statistical tools, such as VAST, where applicable. Information from bycatch species in the research blocks will provide additional life history information for future trophic modelling efforts.

Data collection on marine mammal sightings will be summarized and mapped. Presence/absence as well as abundance will be studied to inform about depredation by marine mammals. Depending on the quality and the amount of data collected, statistical models could be used to infer depredation.

Oceanographic study of the Subarea 48.6 with Sea Surface Temperature (SST) anomaly and vertical Profile of Sea Temperature (PST) will be routinely done, using satellite data as well as in situ (CTDs), as well as an analysis of the Sea Ice Concentration (SIC) in the subarea. This research will improve the understanding of trophic relationships and ecosystem function to assist the development of ecosystem-based fisheries management approaches.

(d) How and when will the data meet the objectives of the research (e.g. lead to a robust estimate of stock status and precautionary catch limits). Include evidence that the proposed methods are highly likely to be successful.

This research plan aims to provide an evaluation that allows managing the toothfish fisheries in the subarea 48.6 by the end of the 2023/24 season. The methods are likely to be successful because the sampling entails normal, but standardized, fishing methodologies and sampling approaches are the usual for vessels and scientific observers.

Additionally, the use of environmental data provided by the CTDs, the BVC system deployed, the PSAT tagged on Antarctic toothfish, the samples collected for genetic and/or fatty acid analysis or the stomach contents sampling, will help to understand which of the three stock hypotheses is more likely for this species and to contribute to model the toothfish habitat and the main bycatch species. Comparisons with expected distributions and summaries of additional information collected (e.g., fishable area distribution, recaptures, encounter rates of VME indicator species) will be included in annual progress reports to CCAMLR WGs.

Results will also be compared with reported information from other exploratory fisheries. Japan, South Africa and Spain will contribute to the development of integrated assessment models with other CCAMLR members by 2024 CCAMLR-WGs meetings. A document with the preliminary results of an integrated stock assessment for research block 486_2 using CASAL has been presented in WG-FSA-2019 (WG-FSA-2019/21).

4. Proposed catch limits

(a) Proposed catch limits and justification (Note that the catch limits should be at a level not substantially above that necessary to obtain the information specified in the Research Plans and required to meet the objectives of the proposed research)

Catch limit in research blocks in exploratory fisheries at Subarea 48.6 will be determined by the Trend Analysis Decision Framework (SC-CAMLR XXXVI, paragraph 3.77-3.78) in 2020 WG-FSA and SC.

Table 4 indicates a research catch allocation among participating Members. The catch allocation will be re-distributed among Members to maximize data collection for each research block, especially tag recovery, if it is necessary; operators will be in constant contact during the fishing season to ensure that the catch limits are taken.

Table 4: The initial catch allocation in percentage of catch limits for the 2021/22 season for research plans in Subarea 48.6 by Research Blocks. *Catch limit to be determined by the Trend Analysis Decision Framework in CCAMLR WGs and SC-CAMLR.

Research block	Catch limit*	Japan	South Africa	Spain
48.6_2		33.3%	33.3%	33.3%
48.6_3		33.3%	33.3%	33.3%
48.6_4		33.3%	33.3%	33.3%
48.6_5		50%	0%	50%

(b) Evaluation of the impact of the proposed catch on stock status:

In the Trend Analysis Decision Framework used by CCAMLR WGs, catch limit is calculated by applying a 4% exploitation rate to the Chapman and/or CPUE by seabed area biomass estimates, including up to the most recent season in which sampling has been completed for each research block (B4%). Therefore, proposed catch would have low impacts on stock status of toothfishes.

Rationale that proposed catch limits are consistent with Article II of the Convention

The proposed research is not expected to have an additional impact on stock status. The

catch limits are based on revised local abundance estimation using the best available scientific data under the Trend Analysis Decision Framework, which are designated to provide reasonable assurance against negative impacts on stock status, consistent with the objectives of CCAMLR and a precautionary approach.

Evaluation of timescales involved in determining the responses of harvested, dependent and related populations to fishing activities

Preliminary results quantifying spatio-temporal variation in bycatch have been presented to WG-SAM-17 (Okuda et al., 2017). Conditional upon CCAMLR review, survey and tag-recovery fishing in 2020/21 season will provide information on the biomass present in fished areas and estimated long-term population responses to fishing activities. Further investigations will be made to compare fishing effort (CPUE) and gear selectivity (toothfish and bycatch), between Japanese and South African trotline and Spanish system within in the 48.6 Subarea.

Information on estimated removals, including IUU fishing activities, where available

This data-poor exploratory toothfish fishery does not allow for an estimation of IUU removals at this point. The area is potentially exposed to high IUU fishing. Any observations of such activity will be reported and extended effort to record potential IUU activity through satellite information will be used to enhance information about such activities. Results of these records will be added to the total catch removed for integration into the ISA models.

(c) Details of dependent and related species and the likelihood of their being affected by the proposed fishery.

Based on the preliminary results quantifying spatio-temporal variation in bycatch by toothfish fishery (Okuda et al., 2017), we anticipate the most common bycatch species group to be *Macrourus* spp. (GRV). Other bycatch species may include Crocodile icefishes (ICX: *Channichthyidae*) and *Antimora rostrata* (ANT).

The proposed research will maintain strict compliance with CCAMLR Conservation Measures regarding bycatch (CMs 41-01, 41-06 and 33-03) and the protection of seabirds and marine mammals (CMs 41-01, 41-06, 25-02 and 25-03). All registered and newly discovered vulnerable marine ecosystems (VMEs) are avoided during fishing operations in accordance with Conservation Measure 22-07. VME-related data are collected and notified in accordance with Conservation Measure 22-06.

5. Research capability

(a) Name(s) and address of the chief scientist(s), research institute or authority responsible for planning and coordinating the research

Japan:

Takehiro Okuda, Yumiko Osawa and Taro Ichii

Fisheries Resources Institute, Japan Fisheries Research and Education Agency

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South African:

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Spain:

Roberto Sarralde Vizuete
Centro Oceanográfico de Canarias of the Instituto Español de Oceanografía (IEO)
San Andrés, Santa Cruz de Tenerife, SPAIN
Phone: +34 922549400
E-mail: roberto.sarralde@ieo.es

(b) Number of scientists and crew to be aboard the vessel

The vessel will carry at least two scientific observers, one of whom shall be appointed in accordance with the CCAMLR Scheme of International Scientific Observation. The other will be an observer appointed by fisheries management body/s of the Members participating in this research. Crew are 35 – 36 people.

(c) Is there opportunity for inviting scientists from other Members?

There is no space available for scientists from other Members aboard the fishing vessels.

(d) Commitment that the proposed fishing vessel(s) and nominated research provider(s) have the resources and capability to fulfil all obligations of the proposed Research Plan

The nominated vessels and on-board scientific observers have the resources and capability to fulfil all obligations of the proposed research plan. For example, the vessels are equipped with the fishing gear and all other facilities required to conduct this research in accordance with relevant conservation measures; as well as communication systems that allow direct telephone, fax, email and internet communication between the vessel and observer coordinators and fishery scientists. The nominated vessels and fishing companies are experienced operating in CCAMLR fisheries, including in Subarea 48.6, Divisions 58.4.1, 58.4.2, and 58.44b, and Subarea 88.1.

Shinsei-maru No.8 (Japan), a new vessel replaced Shinsei-maru No.3 (conducted exploratory fishing in these Divisions since 2008/2009) in 2019/20 fishing season, has been conducting research fishing at 48.6. Crew, scientific observers, and gear (trotline) remained the same from the previous vessel and well experienced to fulfil all obligations of this research plan.

Koryo-Maru No.11 (South African) has been conducting research fishing at 48.6 since 2012/13 season. Crew and scientific observers have well-experienced and able to fulfil all obligations of

this research plan.

The fishing vessel Tronio (Spain) has conducted exploratory fishing in Divisions 58.4.1 and 58.4.2 in five seasons since 2012/13. It has fished in Division 58.4.1 from 2006, always in compliance with conservation measures. Researchers of the Spanish Institute of Oceanography (IEO) have collaborated with CCAMLR since 1986 when a Spanish Scientific Survey was conducted on the Scotia Arc and Antarctic Peninsula.

6. Reporting for evaluation and review

(a) List of dates by which specific actions will be completed and reported to CCAMLR

A progress report will be provided to WG-FSAs annually, with a summary of the data collected in the seasons by all research participants. This report will also contain a preliminary evaluation of catch composition, data collection and tagging activities.

The timeline of milestones is detailed in Table 1.

(b) If research is multi-annual, Members shall commit to providing annual research reviews to be submitted to WG-FSA and/or WG-EMM, including review of progress towards meeting research objectives and associated proposed time lines in initial proposal, and proposals for adjustments to the research proposal if required

The research plan is multi-annual. The progress report submitted to WG-FSA will detail the work completed in the current year and a review of progress towards research objectives. Following discussions during the meetings, adjustments to the research plan will be made.

7. Conservation measure exemptions

(a) Intended exemptions from applicable conservation measures in whole or in part (other than those specified in Conservation Measure 24-01) and justification. Any intended exemptions shall be necessary for the Research Plan and objectives of the proposed research

There is no exemption for this joint research plan.

Proponents commit, in this proposal, to implement any Data Collection Plan developed by the Scientific Committee for the fishery.

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Appendix 1

CCAMLR Research Plan – Research Proponent Self-Assessment Form

Subarea/division:	48.6
Proposal:	This paper
Members:	JPN, ESP, ZAF
Conservation measure under which the proposal is submitted:	21-02
Time period:	2021/22‑2023/24
Main species of interest:	TOA
Main purpose of the research (e.g. abundance, population structure, movement, …)	Abundance
Is the purpose of the research linked to Commission or Scientific Committee priorities?	Y: section 1.a
1. Quality of the proposal	
1.1 Is there enough information to evaluate the likelihood of success of the research objectives?	Y: all of this proposal
2. Research design	
2.1 Is the proposed catch limit in accordance with research objectives?	Y: section 3.d, 4.a, and 4.b
2.2 Is the sampling design appropriate to achieve research objectives?	Y: section 3.b
2.3 Have the environmental conditions been thoroughly accounted for?	Y: section 3.b
3. Research capacity	
3.1 Have the research platforms demonstrated experience in:	
3.1.1 Conducting research/exploratory fishing following a research plan?	Y: section 5
3.1.2 Collecting scientific data?	Y: section 5
3.2 Do the research platforms have acceptable tag detection and survival rates?	Y: WG-FSA-17/36 and WG-FSA-2019 report (Figure 7). Shinsei-maru No.8 is a new vessel, same gear and crew that the withdrawn Shinsei-maru No.3.
3.3 Have the research teams sufficient resources and capacity for:	
3.3.1 Sample processing?	Y: section 1.c
3.3.2 Data analyses?	Y: section 1.c
4. Data analyses to address the research questions	
4.1 Are the proposed methods appropriate?	Y: section 1.a and 3.c
5. Impact on ecosystem and harvest species	
5.1 Is the catch limit proposed consistent with Article II of the Convention?	Y: section 3.d, 4.a, and 4.b
5.2 Are the impacts on dependent and related species accounted for and consistent with Article II of the Convention?	Requires more analysis on by-catch populations, see WG-SAM-2019/09 (WG-FSA-2019 report Table 8): section 3.b
6. Progress towards objectives for ongoing proposals	
6.1 Have the past and current milestones been completed?	Y: Section 1.c, and WG-FSA-2019/23 Rev. 1 Appendix 1
6.2 Has previous advice from the Scientific Committee and its working groups been addressed?	Y: WG-FSA-38 report, para 4.58
6.3 Are all the objectives likely to be completed by the end of the research plan?	Y: Table 1
6.4 Are there any other concerns?	N

Appendix 2: Vessel tagging procedures survey

All vessels follow the CCAMLR tagging protocol for tagging toothfish (www.ccamlr.org/node/85702).

[Shinsei-maru No.8]

Equipment and operation	
Tagging station location	On deck – Open air: **N**
	On deck – Under cover: **Y（in the hauling station)**
	In factory: **N**
	Other – Please describe:
	How frequently are tagging guns cleaned or maintained? : **Every haul**
	Vertical distance from water surface to hauling bay (m): **about 3m**
	Vertical distance from fish release position to water surface (m): **about 3m**
	Distance from tagging station to release location (m): **within 1m**
Holding tank	**Y**
Holding tank information (if used)	Volume (l): **1.5 ㎥**
	Shape (square, rectangle, circle etc.): **rectangle**
	Does the tank have flowing water (Y/N): **Y**
Landing and handling fish	
Large fish landing and lifting equipment	Net: **N**
	Stretcher or cradle: **cradle**
	Other – Please describe:
	Approximate minimum length of fish when lifting gear is used (cm): **70cm**
Transporting fish	When transporting the fish between the hauling bay and the tagging station, are any of the following obstacles present: • Bulkheads: **N** • Machinery: **N** • Factory equipment (e.g. conveyor belts): **N** • Steps or multiple levels: **N** Any other obstruction? **N**
	Is lifting equipment used to carry fish between hauling bay and tagging station? (Y/N): **Y**
How are tagging data recorded at the tagging station?	Direct to computer/Paper data sheet/waterproof board or notepad/Photograph/Other: **waterproof board**
Releasing fish	Describe any aides used for release of fish (e.g. cradle, slide): **No aides used**
Personnel and training	
Tagging responsibilities	Crew: **N**
	Observer(s): **N**
	Combination: **Y**
	Number of crew trained for tagging procedures: **8**
	If any tagging training occurs on the vessels is it practical, theoretical or a combination? : **practical**
	Languages by crew trained for tagging: **Indonesia**

	Title of person responsible for overall tagging training (e.g. fishing master, bosun, factory manager, observer, company representative/other): **bosun**
	When a tagged fish is landed and the observer is not present, how is the observer notified? : **call the observer**
Assessment of fish suitability for tagging	CCAMLR tagging protocol and fish suitability assessment criteria available for viewing near tagging station: (Y/N): **Y**

[Koryo maru No.11]

Equipment and operation	
Tagging station location	On deck – Open air: **N**
	On deck – Under cover: **Y （in the factory)**
	In factory: **Y**
	Other – Please describe:
	How frequently are tagging guns cleaned or maintained? : **Daily**
	Vertical distance from water surface to hauling bay (m): **about 3m**
	Vertical distance from fish release position to water surface (m): **about 3m**
	Distance from tagging station to release location (m): **within 4 m**
Holding tank	**Y**
Holding tank information (if used)	Volume (l): **2 ㎥**
	Shape (square, rectangle, circle etc.): **rectangle**
	Does the tank have flowing water (Y/N): **Y**
Landing and handling fish	
Large fish landing and lifting equipment	Net: **Y**
	Stretcher or cradle: **cradle**
	Other – Please describe:
	Approximate minimum length of fish when lifting gear is used (cm): **90 cm**
Transporting fish	When transporting the fish between the hauling bay and the tagging station, are any of the following obstacles present: • Bulkheads: **Y** • Machinery: **N** • Factory equipment (e.g. conveyor belts): **N** • Steps or multiple levels: **N** Any other obstruction? **N**
	Is lifting equipment used to carry fish between hauling bay and tagging station? (Y/N): **Y**
How are tagging data recorded at the tagging station?	Direct to computer/Paper data sheet/waterproof board or notepad/Photograph/Other: **waterproof board**
Releasing fish	Describe any aides used for release of fish (e.g. cradle, slide): **No aides used**
Personnel and training	
Tagging responsibilities	Crew: **Y**
	Observer(s): **Y**
	Combination: **Y**
	Number of crew trained for tagging procedures: **6** to **8**
	If any tagging training occurs on the vessels is it practical, theoretical or a combination? : **combination**
	Languages by crew trained for tagging: **Afrikaans**/**English**
	Title of person responsible for overall tagging training (e.g. fishing master, bosun, factory manager, observer, company representative/other): **bosun OR The observers usually shows/trains the factory crew when they assists with the tagging sessions.**
	When a tagged fish is landed and the observer is not present, how is the observer notified? : **The factory/hauling station crew notifies the officer on duty to call the observer for tag recoveries**.

Assessment of fish suitability for tagging	CCAMLR tagging protocol and fish suitability assessment criteria available for viewing near tagging station: (Y/N): **Y**

[Tronio]

Equipment and operation	
Tagging station location	On deck – Open air: **Y**
	On deck – Under cover: **N**
	In factory: **N**
	Other – Please describe:
	How frequently are tagging guns cleaned or maintained? Every haul, periodically, once per trip **Periodically**
	Vertical distance from water surface to hauling bay (m): 3m
	Vertical distance from fish release position to water surface (m): 4m
	Distance from tagging station to release location (m): 1m
Holding tank	Y
Holding tank information (if used)	Volume (l): 1.15m^3
	Shape (square, rectangle, circle etc.): Rectangle
	Does the tank have flowing water (Y/N): Y
Landing and handling fish	
Large fish landing and lifting equipment	Net: **Y**
	Stretcher or cradley. **Craddle**
	Other – Please describe:
	Approximate minimum length of fish when lifting gear is used (cm): **115cm**
Transporting fish	When transporting the fish between the hauling bay and the tagging station, are any of the following obstacles present: • Bulkheads: **N** • Machinery: **N** • Factory equipment (e.g. conveyor belts): **N** • Steps or multiple levels: **Another level for the small specimens that are manually lifted. The bigger ones are recovered directly in the upper level.** Any other obstruction? **N**
	Is lifting equipment used to carry fish between hauling bay and tagging station? (Y/N): **N**
How are tagging data recorded at the tagging station?	Direct to computer/Paper data sheet/waterproof board or notepad/Photograph/Other: **waterproof board**
Releasing fish	Describe any aides used for release of fish (e.g. cradle, slide): **Craddle for the >115cm**
Personnel and training	
Tagging responsibilities	Crew: **N**
	Observer(s): **Y**
	Combination: **N**
	Number of crew trained for tagging procedures: **No crew trained**
	If any tagging training occurs on the vessels is it practical, theoretical or a combination? -
	Languages by crew trained for tagging: -
	Title of person responsible for overall tagging training (e.g. fishing master, bosun, factory manager, observer, company representative/other): -
	When a tagged fish is landed and the observer is not present, how is the

	observer notified? The smaller ones They put it in the tank...for t. For the bigger fishing master shouts to the observer.
Assessment of fish suitability for tagging	CCAMLR tagging protocol and fish suitability assessment criteria available for viewing near tagging station: (Y/N): **Y**

PHOTO OF TAGGING PROCEDURES